INDOOR AIR QUALITY ASSESSMENT

Southeast Middle School
95 Viscoloid Avenue
Leominster, MA 01453

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response Indoor Air Quality Program

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Background/Introduction

At the request of the Leominster Health Department, the Massachusetts Department of Public Health's (MDPH) Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality at each of Leominster's public schools. These assessments were jointly coordinated through Chris Knuth, Director of the Leominster Health Department, and David Wood, Facilities Director for Leominster Public Schools (LPS). On June 9, 2005, Sharon Lee, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an assessment at the Southeast Middle School (SMS), 95 Viscoloid Avenue, Leominster, Massachusetts.

The SMS is a split-level, one-story red brick building constructed in 1970. Modular classrooms were added in the mid 1980s. Windows are openable throughout the building.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). CEH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The SMS houses grades 5 through 8, with a student population of approximately 570 and a staff of approximately 70. Tests were taken under normal operating conditions. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million (ppm) in eleven of thirty-six areas surveyed, indicating adequate air exchange in the majority of areas surveyed on the day of the assessment. However, some areas with carbon dioxide levels below 800 ppm were sparsely populated, unoccupied and/or had windows open, which can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to be higher with full occupancy and with windows shut.

Fresh air in classrooms in the main building is supplied by unit ventilator (univent) systems (Pictures 1 and 2) equipped with high efficiency pleated filters (Picture 3). Filters are reportedly changed during each school vacation. Each filter is dated for the date change. Of the univent filters examined, some filters were not dated, and one was dated for February 2005 (the last school vacation was April 2005) (Picture 3).

A univent is designed to draw air from outdoors through a fresh air intake located on the exterior wall of the building (Picture 4). Return air is drawn through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. A number of univents were found deactivated during the assessment (Table 1). Obstructions to airflow, such as papers and books stored on univents and bookcases, carts and desks in front of univent returns, were seen in several classrooms (Picture 5). In order for univents to provide fresh air as designed, units must be activated and remain free of obstructions. Mechanical exhaust ventilation for classrooms in the main building is provided by wall-mounted vents powered by rooftop motors (Pictures 6 and 7). These vents were operating in all classrooms surveyed. However, a number of exhaust vents were obstructed by various classroom items impeding airflow (Picture 6).

Mechanical ventilation in the gymnasium is provided by a rooftop/ceiling-mounted air-handling unit (AHU). Air is distributed by ducted ceiling vents and returned to the AHU through a ducted wall vent. The system was not operating during the assessment, which can indicate that the AHU was deactivated or non-functional.

Ventilation for modular classrooms is provided by AHUs mounted on the exterior wall of the building (Picture 8). Fresh air is distributed to classrooms via ductwork connected to ceiling-mounted air diffusers (Picture 9) and drawn back to the units through wall-mounted grilles (Picture 10). Thermostats control each heating, ventilating and air conditioning (HVAC) system and have fan settings of "on" and "automatic". Thermostats were set to the "automatic" setting during the assessment. The automatic setting on the thermostat activates the HVAC system at a preset temperature. Once the preset temperature is reached, the HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system. It is also important to note that classrooms are equipped to provide chilled air in warm weather, which limits outside air intake on hot, humid days (as was the case during the assessment). Limiting outside air intake can contribute to an increase in carbon dioxide levels.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). It was reported by Mr. Wood that the LPS has a contract with Pioneer Valley Environmental, Inc., an HVAC engineering firm that conducts preventive maintenance of HVAC equipment in all of Leominster's public schools. The preventative maintenance program consists of an annual assessment of all HVAC system components (e.g., univents, AHUs, pneumatic controls, thermostats). A detailed report is generated and provided to the LPS facilities department to address needs.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is

5,000 ppm. Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix A.

Temperature readings ranged from 72^{o} F to 82^{o} F, which were above the MDPH comfort guidelines of 70^{o} F to 78^{o}. The MDPH recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. During hot weather, it is difficult to meet these recommendations without the aid of air conditioning (main building), or while operating air-conditioning with window and exterior doors open (modular building). In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, it is also difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (i.e., deactivated and/or obstructed).

The relative humidity measurements ranged from 60 to 73 percent, which were above the MDPH recommended comfort range the day of the assessment. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. These relative humidity readings would be expected with an outdoor relative humidity of 78 percent. As is the case with temperature, it is difficult to maintain relative humidity without the aid of air conditioning and/or dehumidification during hot, humid weather. Relative humidity in excess of 70 percent can provide an environment for mold and fungal growth (ASHRAE, 1989). During periods of high relative humidity (late spring/summer months), windows and exterior doors to the modular building should be closed to keep moisture out when the HVAC system is air conditioning mode. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several areas had water-stained ceiling tiles, which can indicate leaks from the roof or plumbing system (Picture 11). Water-damaged ceiling tiles can provide a source for mold and should be replaced after a water leak is discovered and repaired. Open seams between the sink countertop and backsplash were observed in several rooms (Picture 12). If not watertight, water can penetrate through the seam, causing water damage. Water penetration and chronic exposure of porous and wood-based materials can cause these materials to swell and show signs of water damage.

Plants were noted in several classrooms, and flowering plants were seen in close proximity to univent air intakes (Pictures 1 and 13). Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from ventilation sources (e.g., air intakes, univent diffusers) to prevent the entrainment and/or aerosolization of dirt, pollen or mold.

Plants were observed to be growing against exterior walls (Picture 14). The growth of roots against exterior walls can bring moisture in contact with the foundation. Plant roots can eventually penetrate, leading to cracks and/or fissures in the sublevel foundation. Over time, this process can undermine the integrity of the building envelope, providing a means of water entry into the building via capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

MDPH staff examined the building exterior and observed several downspouts missing from the drainage/gutter system (Picture 15). Sections of the exterior walls appeared to be saturated with moisture. Excessive exposure of exterior brickwork to water can result in damage over time.

Several classrooms contained aquariums and terrariums (Picture 16). Aquariums should be properly maintained to prevent microbial/algae growth, which can emit unpleasant odors. Similarly, terrariums should be properly maintained to ensure soil does not become a source for mold growth.

As discussed, the air-conditioning in the modular building was operating with windows and exterior doors open. As a result, condensation was observed on a number of windows (Picture 17). Over time, chronic condensation can result in damage to the building materials.

Other IAQ Evaluations

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient-Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were measured at 2 ppm (Table 1), with the most likely source being exhaust emissions from idling vehicles outside the building. Carbon monoxide levels measured in the school ranged from non-detect to 2 ppm (Table 1). Areas with measurable levels of carbon monoxide are most likely the result of vehicle exhaust emissions being drawn in through the ventilation system of natural infiltration through windows.

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, the MDPH uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 80 $\mu g/m^3$ (Table 1), which were above the NAAQS of 65 $\mu g/m^3$. PM2.5 levels measured indoors ranged from 20 to 93 $\mu g/m^3$ (Table 1), which was also above the NAAQS of 65 $\mu g/m^3$ in some areas. Outdoor PM2.5 concentrations for the Worcester MA area were moderate (51-100 $\mu g/m^3$) (AirNow, 2005). Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors.

A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC measurements throughout the building were also ND, with the exception of two rooms that had readings of 0.2 ppm and 0.4 ppm (Table 1) from the use of dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999). Cleaning products and air deodorizers were found on countertops in some classrooms. Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals.

Cleaning products were found on countertops and in unlocked cabinets beneath sinks in some classrooms. Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. Also of concern are unlabelled bottles and containers. Products should be kept in their original containers and be clearly labeled for identification purposes, especially in the event of an emergency. Also in use were plug-in air deodorizers and scented candles, which contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. Furthermore, air fresheners do not remove materials causing odors, but rather mask odors that may be present in the area.

Several other conditions that can potentially affect indoor air quality were identified. Pest attractants were identified within the building. A popcorn machine (Picture 17), food-based projects and re-use of food containers were observed. Proper food storage is an integral component in maintaining indoor air quality. Food should be properly stored and clearly labeled. Reuse of food containers is not recommended since food residue adhering to the surface may serve to attract pests.

Accumulated chalk dust was noted in some classrooms. Chalk dust is a fine particulate, which can be easily aerosolized and is an eye and respiratory irritant. Missing ceiling tiles and items hanging from ceiling tiles were seen a few areas. Missing and/or the movement of ceiling tiles can serve as pathways for dust, dirt, odors and other pollutants to move into occupied areas.

Also of note was the amount of materials stored in some classrooms. Items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. Dust was also noted on the blades of personal fans. The fan blades should be cleaned periodically to prevent aerosolization when fans are activated are moved. Dust can be irritating to eyes, nose and respiratory tract.

In an effort to reduce noise from sliding chairs, tennis balls had been cut open and placed on chair legs (Picture 19). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and cause off-gassing of VOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix C (NIOSH, 1998). Consider replacing tennis balls with alternative glides (Picture 20).

Finally, some classrooms contained upholstered furniture and pillows. Upholstered furniture is covered with fabric that encounters human skin. This type of contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. In addition, if relative humidity levels increase above 60 percent (e.g., during spring/summer), dust mites tend to proliferate (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, 1994). It is also recommended that if upholstered furniture were present in schools, it should be professionally cleaned on an annual basis or every six months if dusty conditions exist outdoors (IICR, 2000).

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made to improve general indoor air quality:

1. Examine each univent for function. Operate univents while classrooms are occupied. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.
2. Examine exhaust vents for function and make repairs as necessary.
3. Operate all ventilation systems that are operable throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control to maximize air exchange.
4. Remove all obstructions from univents and exhaust vents to facilitate airflow. Close classroom doors to improve air exchange.
5. Set thermostats for modular classrooms to the fan "on" setting to provide continuous air exchange.
6. Use openable windows in conjunction with classroom exhaust vents to facilitate air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended.

Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

8. Ensure roof and/or plumbing leaks are repaired, and replace/repair water damaged building materials. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
9. Replace missing downspout. Examine gutter/downspout system periodically to ensure gutters are free of debris, and downspouts are intact.
10. Remove plants growing against building and its foundation to prevent water intrusion through brickwork.
11. Clear plant growth and other materials/debris away from the proximity of univent air intakes.
12. Examine plants in classrooms for mold growth in water catch basins. Disinfect water catch basins if necessary. Remove plants from ventilation sources and/or carpeted areas.
13. Clean and maintain aquariums and terrariums to prevent bacterial/microbial growth and associated odors.
14. Seal seems between sink countertops and backsplash to prevent water damage and/or microbial growth.
15. Store and label food appropriately. Refrain from re-using food and/or containers as project materials to prevent pest attraction.
16. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

17. Clean chalkboard/dry erase marker trays regularly to prevent the build-up of excessive chalk dust and particulates.
18. Clean upholstered furniture on the schedule recommended in this report. If not possible/practical, remove upholstered furniture from classrooms.
19. Replace missing ceiling tiles.
20. Refrain from hanging objects from ceiling tile systems.
21. Consider adopting the US EPA (2000b) document, "Tools for Schools", to maintain a good indoor air quality environment in the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
22. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website: http://mass.gov/dph/indoor_air

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Picture 1

Classroom Univent, Note Plants on Unit

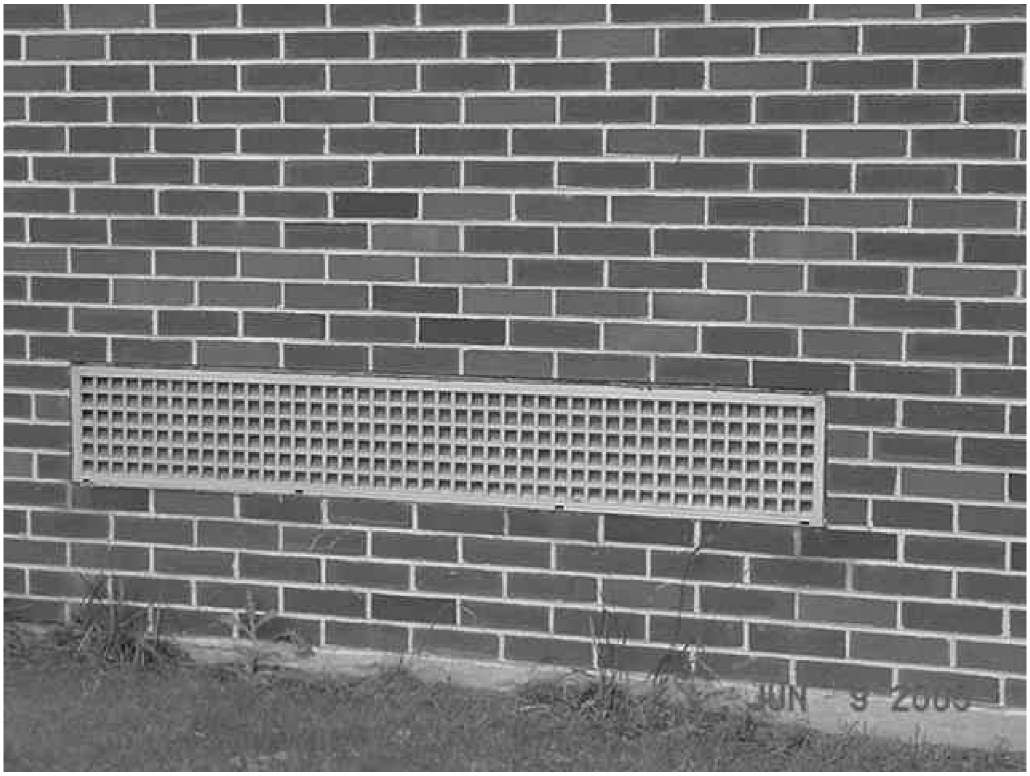
Picture 2

Ceiling-Mounted Univent

Picture 3

High-Efficiency Pleated Air Filters in Univent

Picture 4



Univent Fresh Air Intake

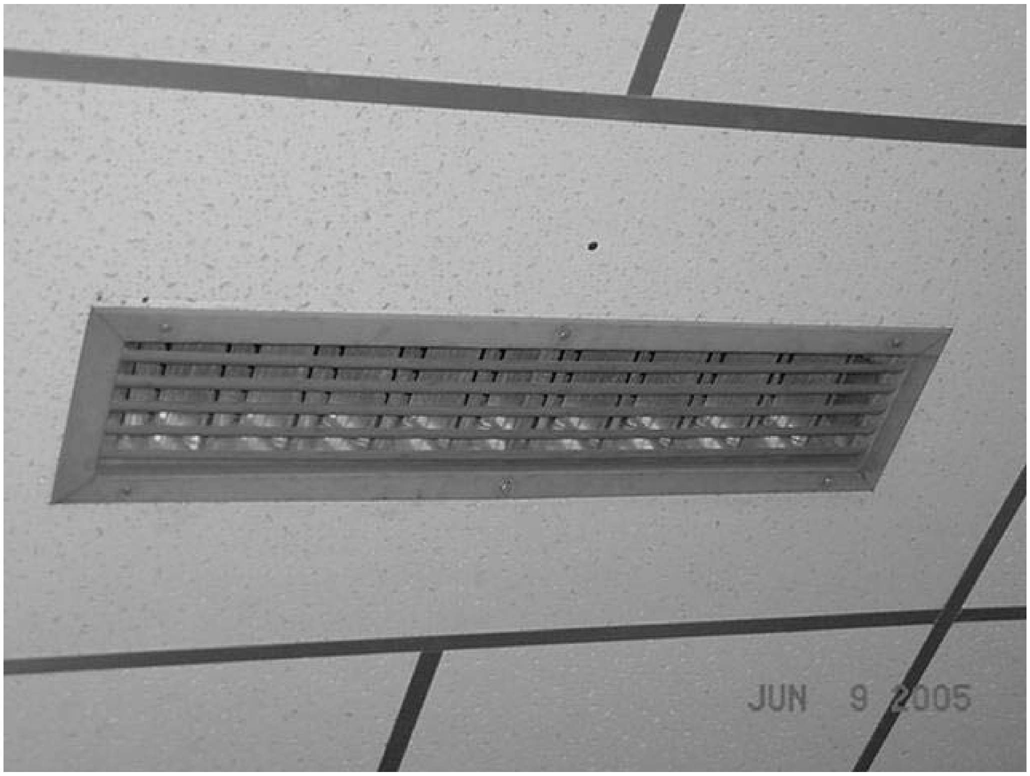
Picture 5

Univent Obstructed by Various Items

Picture 6

Obstructed Wall-Mounted Exhaust Vent in Classroom

Picture 7



Ceiling-Mounted Exhaust Vent

Picture 8

Modular Air Handling Unit

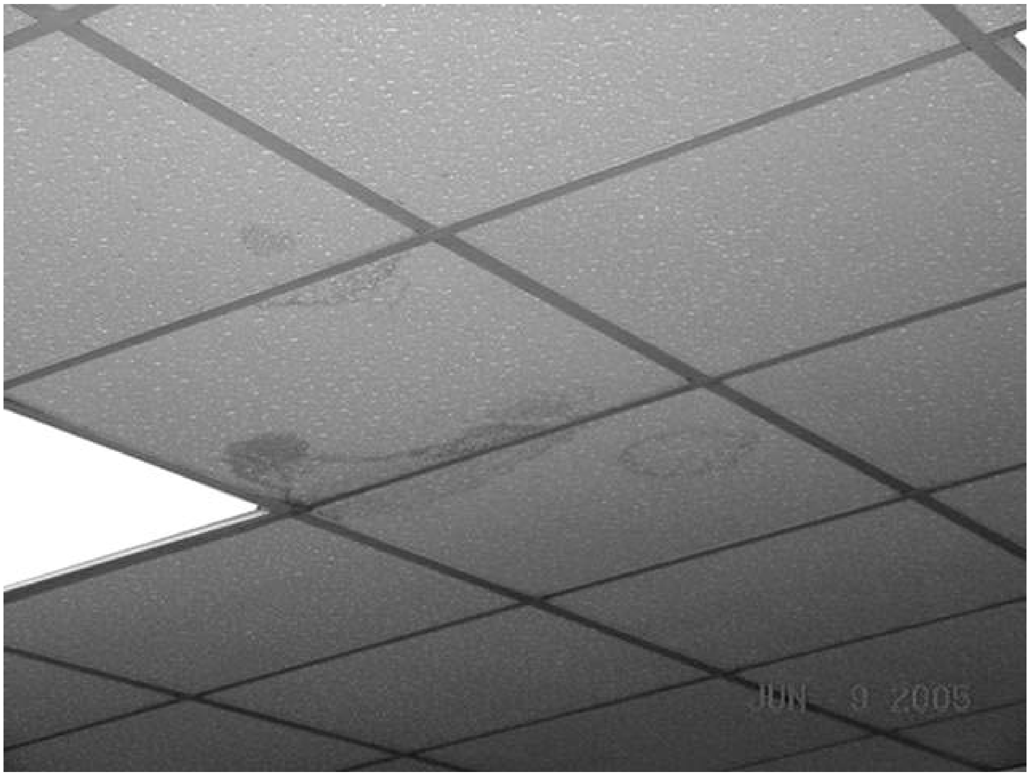
Picture 9

Ceiling-Mounted Air Diffuser for Modular Classroom

Picture 10

Return Vent for Modular Air Handling Unit

Picture 11



Water Damaged Ceiling Tiles

Picture 12

Space Between Classroom Sink and Backsplash

Picture 13

Plants and Potting Soil on Fresh Air Diffuser

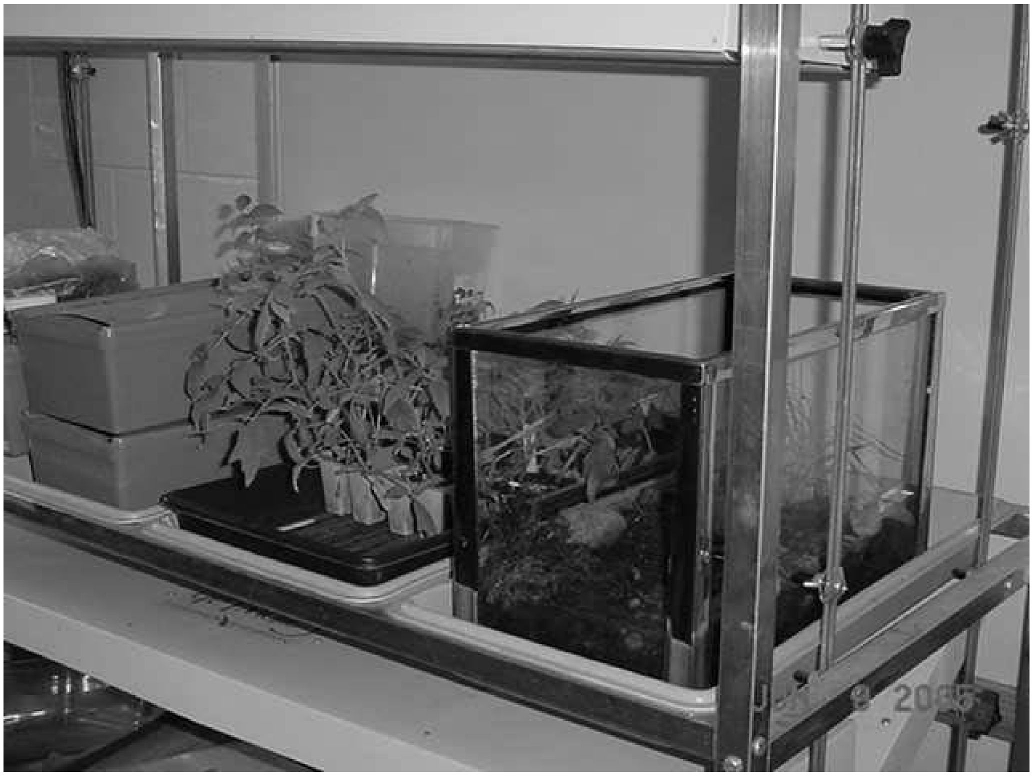
Picture 14

Plants Growing between Tarmac and Exterior Walls

Picture 15

Missing Downspout/Elbow

Picture 16

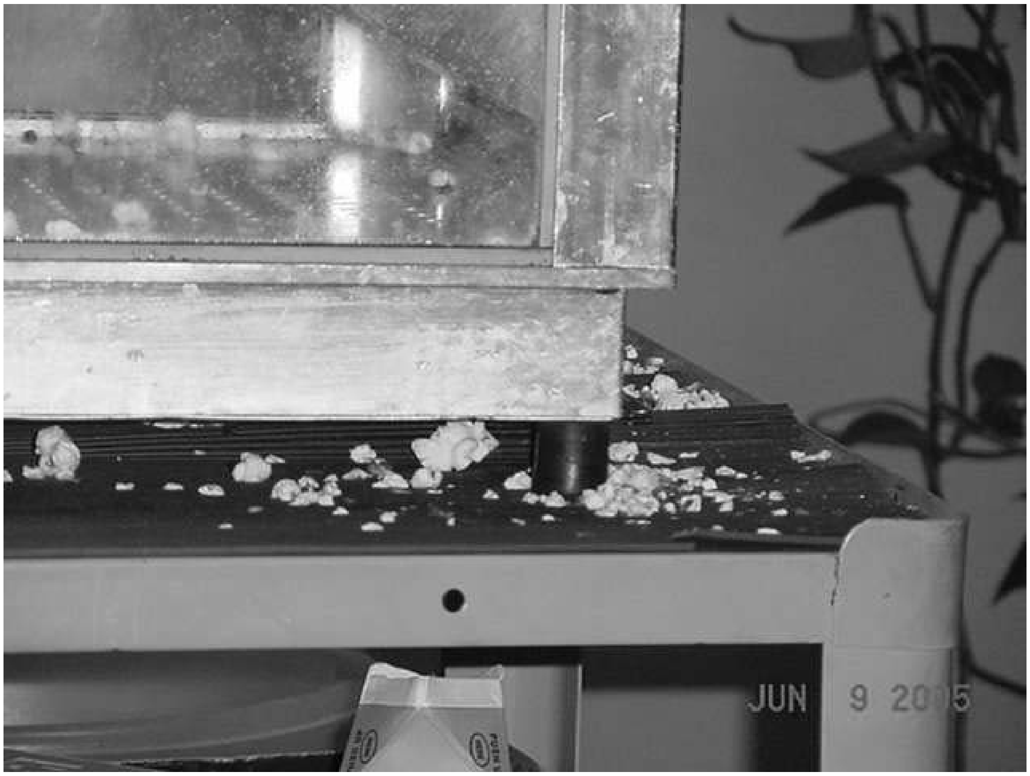


Terrarium and Plants in Classroom

Picture 17

Condensation on Windows in Modular Classroom

Picture 18

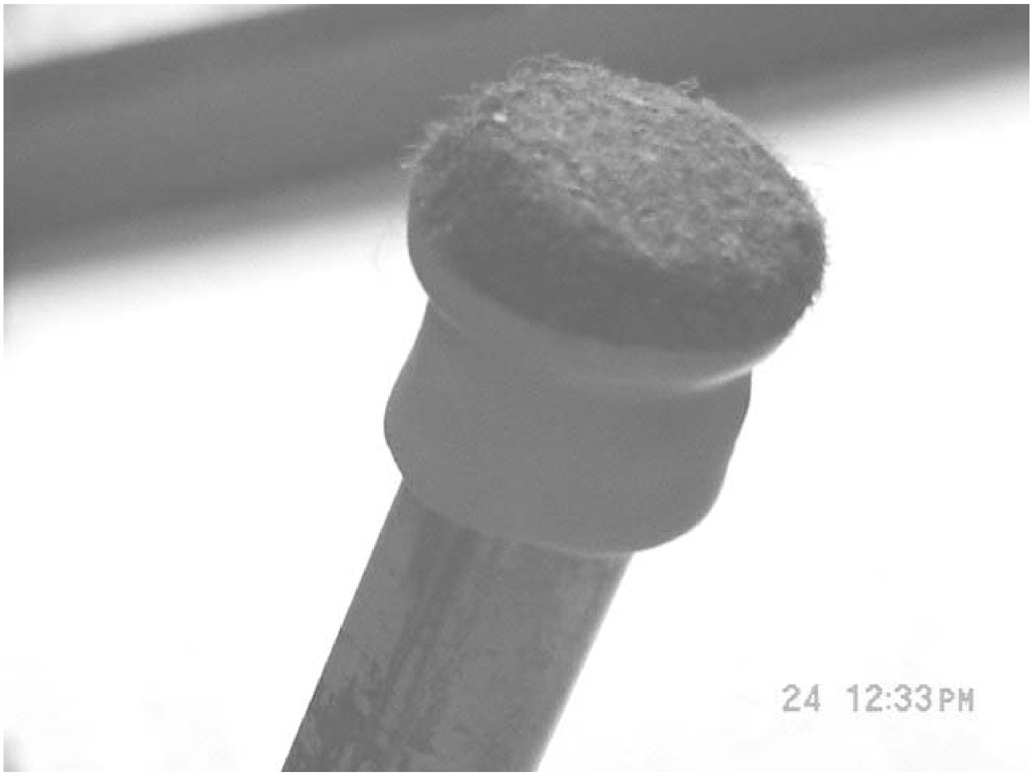


Popcorn Machine

Picture 19

Tennis Ball on Chair Leg

Picture 20



"Glides" for Chair Legs that can be used as an Alternative to Tennis Balls

Southeast Middle School **Indoor Air Results**

95 Viscoloid Avenue, Leominster, MA 01453 **Table 1** **Date: 06/09/2005**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background		75	78	459	2	ND	80				Cars idling (7) outside building, school near major roadway.
cafeteria	7	78	73	607	ND	ND	93	N	Y univent	Y wall	Exterior DO
guidance	2	78	66	582	ND	ND	67	Y # open: 0 # total: 1	Y ceiling	Y ceiling	Exterior DO, #WD-CT: 1, breach sink/counter, AD, DEM, scented candles.
gym	60	80	67	666	ND	ND	88	N # open: 0 # total: 0	Y ceiling (off)	Y wall (off)	Hallway DO, Exterior DO, DEM.
LA Room	1	81	66	746	ND	ND	76	Y # open: 1 # total: 1	Y univent (off)	Y ceiling	Hallway DO, AP, DEM.
media	40	81	64	575	ND	ND	67	Y # open: 5 # total: 7	Y univent (off) items	Y ceiling	ceiling fans.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

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									Supply	Exhaust	
nurse	5	78	68	718	2	ND	42	Y # open: 1 # total: 1	N	N	Hallway DO, plants.
5/6 resource	0	75	66	567	ND	ND	36	Y # open: 0 # total: 2	Y univent	Y ceiling	Inter-room DO
10	3	78	67	535	1	0.2	71	Y # open: 1 # total: 2	Y univent dust/debris plant(s)	Y wall	Exterior DO, cleaners, items, FC re-use, food use/storage.
11 life skills	12	78	68	650	1	ND	71	Y # open: 2 # total: 2	Y univent plant(s)	Y wall (off)	#WD-CT: 2, DEM, PF, food use/storage, plants.
20	18	80	69	702	ND	ND	75	Y # open: 2 # total: 2	Y univent items	Y ceiling	Hallway DO, breach sink/counter, DEM, PF, items.
21	27	80	68	846	ND	0.4	80	Y # open: 2 # total: 2	Y univent (off) furniture	Y ceiling	Hallway DO, #WD-CT : 1, breach sink/counter, DEM, PF, items hanging from CT, heavy DEM odors.

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Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Southeast Middle School **Indoor Air Results**

95 Viscoloid Avenue, Leominster, MA 01453 **Table 1** **Date: 06/09/2005**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
22	21	79	70	745	ND	0.1	78	Y # open: 2 # total: 2	Y univent (off) items	Y ceiling	Hallway DO, DEM, PF.
23	25	79	68	748	ND	ND	77	Y # open: 2 # total: 2	Y univent dust/debris	Y ceiling	Hallway DO, CD, DEM, PF, items hanging from CT, plants.
24	22	81	68	794	ND	ND	75	Y # open: 2 # total: 2	Y univent	Y ceiling	Hallway DO, breach sink/counter, DEM, PF.
25	14	79	66	701	ND	ND	74	Y # open: 2 # total: 2	Y univent items furniture plant(s)	Y ceiling	Hallway DO, breach sink/counter, DEM, PF.
27	0	79	67	586	ND	ND	74	Y # open: 2 # total: 2	Y univent (off) furniture plant(s)	Y ceiling	DEM, PF.

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									Supply	Exhaust	
28	21	81	67	808	ND	ND	71	Y # open: 2 # total: 2	Y univent	Y ceiling	Hallway DO, PF, aqua/terra, food use/storage, items hanging from CT, plants.
29	18	81	70	1261	ND	ND	69	Y # open: 2 # total: 2	Y univent plant(s)	Y ceiling	Hallway DO, AD, DEM, PF, items hanging from CT, chem odors.
30	24	81	72	1015	ND	ND	82	Y # open: 2 # total: 2	Y univent	Y ceiling	DEM, TB, heavy foot traffic.
31	0	80	67	680	ND	ND	69	Y # open: 1 # total: 1	Y univent	Y ceiling	Hallway DO, DEM, PF.
32	16	82	73	1335	ND	ND	79	Y # open: 0 # total: 2	Y univent boxes items furniture	Y ceiling	Hallway DO, #WD-CT : 2, #MT/AT: 1, DEM, items, dust, plants.
33	22	79	69	876	ND	ND	68	Y # open: 2 # total: 3	Y univent	Y ceiling	#WD-CT: 1, DEM, PF.

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									Supply	Exhaust	
34	24	81	72	1183	ND	ND	69	Y # open: 2 # total: 2	Y univent	Y ceiling	Hallway DO, DEM, PF.
35	2	78	66	507	ND	ND	72	Y # open: 3 # total: 3	Y univent dust/debris	Y ceiling	Hallway DO, DEM, plants.
36	20	81	67	779	ND	ND	70	Y # open: 2 # total: 2	Y univent	Y ceiling	Hallway DO, DEM, PF, plants.
37	24	81	67	805	ND	ND	72	Y # open: 1 # total: 1	Y univent (off)	Y ceiling	Hallway DO, DEM, PF, cleaners.
38	21	81	68	925	ND	ND	72	Y # open: 2 # total: 2	Y univent items	Y ceiling	DEM, PF, cleaners.
39	22	80	71	873	ND	ND	69	Y # open: 2 # total: 2	Y univent items furniture	Y ceiling	Hallway DO, DEM, PF, plants.

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Southeast Middle School | **Indoor Air Results**

95 Viscoloid Avenue, Leominster, MA 01453 | **Date: 06/09/2005**

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									Supply	Exhaust	
40	0	79	67	614	ND	ND	74	Y # open: 2 # total: 2	Y univent plant(s)	Y ceiling	Hallway DO, #WD-CT: 2.
41	0	78	69	454	ND	ND	78	N	Y univent plant(s)	Y ceiling	DEM, PF, items.
43	22	80	66	643	ND	ND	73	Y # open: 2 # total: 2	Y univent items	Y ceiling	Hallway DO, AP, DEM, PF, plants.
44	25	80	67	849	ND	0.2	69	Y # open: 2 # total: 2	Y univent (off)	Y ceiling	DEM, PF, FC re-use, DEM in use-odors.
45	0	80	65	578	ND	ND	68	Y # open: 2 # total: 2	Y univent	Y ceiling	Hallway DO, Inter-room DO, CD, DEM, PF, FC re-use.
46	0	79	66	623	ND	ND	66	Y # open: 1 # total: 2	Y univent items	Y ceiling	Hallway DO, DEM, PF, FC re-use.
51	2	72	63	660	ND	ND	20	Y # open: 0 # total: 1	Y ceiling	Y ceiling	#WD-CT: 2, DEM.

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									Supply	Exhaust	
52	1	73	60	605	ND	ND	20	Y # open: 0 # total: 2	Y ceiling wall	Y ceiling	Inter-room DO, #MT/AT: 1, DEM, UF, plants

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